Remarks

Reconsideration of this Application is respectfully requested.

Upon entry of the foregoing amendment, claims 2-5, 7, 9, 10, and 13-16 are pending in the application, with claims 3 and 9 being the independent claims. Claims 2-5, 7, 9, and 10 are sought to be amended. New claims 13-16 are sought to be added. These changes are believed to introduce no new matter, and their entry is respectfully requested.

Based on the above amendments and the following remarks, Applicant respectfully requests that the Examiner reconsider all outstanding rejections and that they be withdrawn.

Reclamations

The August 31, 2004, Reply

In the Amendment and Reply Under 37 C.F.R. § 1.111 filed August 31, 2004, (hereinafter "the August 31, 2004, Reply") Applicant amended claim 3 to add the features of determining a viewing position that is independent of an angle formed between a first direction the viewing position to the scene and a second direction that coincides with a boundary of a rectangular subvolume and communicating the viewing position to a graphics processing unit to distinguish claim 3 from the teachings of U.S. Patent No. 6,532,017 to Knittel *et al.* (hereinafter "Knittel") and U.S. Patent No. 5,794,016 to Kelleher (hereinafter "Kelleher"). Claim 9 was amended in a similar manner.

However, in addition to this distinction, neither Knittel nor Kelleher, alone or in combination, discloses, teaches, or suggests allocating, to multiple graphics processing units, three-dimensional computer graphics data such that the allocated three-dimensional computer graphics data corresponds to a portion of a scene that lies within rectangular subvolumes to which the multiple graphics processing units have been assigned, wherein a measure of a first dimension of a first rectangular subvolume of the rectangular subvolumes is different from a measure of the first dimension of a second rectangular subvolume of the rectangular subvolumes.

Because the feature wherein a measure of a first dimension of a first rectangular subvolume of the rectangular subvolumes is different from a measure of the first dimension of a second rectangular subvolume of the rectangular subvolumes is sufficient to render each of claims 3 and 9 patentable over Knittel and Kelleher, Applicant, in the present Amendment and Reply Under 37 C.F.R. 1.111, amended each of claims 3 and 9 to delete the features of determining a viewing position and communicating the viewing position to the multiple graphics processing units.

Applicant affirmatively rescinds the distinction from the teachings of Knittel and Kelleher based upon the features of determining a viewing position that is independent of an angle formed between a first direction the viewing position to the scene and a second direction that coincides with a boundary of a rectangular subvolume and communicating the viewing position to a graphics processing unit.

The July 1, 2005, Reply

In the Amendment and Reply Under 37 C.F.R. § 1.111 filed July 1, 2005, (hereinafter "the July 1, 2005, Reply") Applicant amended claim 3 to delete the features of determining a viewing position and communicating the viewing position to the graphics processing unit and to add the feature of image combiners, wherein outputs from the multiple graphics processing units are direct inputs to first stage image combiners and outputs from at least two of the first stage image combiners are direct inputs to a second stage image combiner to distinguish claim 3 from the teachings of Knittel, Kelleher, and U.S. Patent No. 6,597,363 to Duluk, Jr. *et al.* (hereinafter "Duluk"). Claim 9 was amended in a similar manner.

However, in addition to this distinction, none of Knittel, Kelleher, or Duluk, alone or in combination, discloses, teaches, or suggests allocating, to multiple graphics processing units, three-dimensional computer graphics data such that the allocated three-dimensional computer graphics data corresponds to a portion of a scene that lies within rectangular subvolumes to which the multiple graphics processing units have been assigned, wherein a measure of a first dimension of a first rectangular subvolume of the rectangular subvolumes is different from a measure of the first dimension of a second rectangular subvolume of the rectangular subvolumes.

Because the feature wherein a measure of a first dimension of a first rectangular subvolume of the rectangular subvolumes is different from a measure of the first dimension of a second rectangular subvolume of the rectangular subvolumes is sufficient to render each of claims 3 and 9 patentable over Knittel, Kelleher, and Duluk, Applicant, in the present Amendment and Reply Under 37 C.F.R. 1.111, amended each of claims 3 and 9 to delete the

feature of image combiners, wherein outputs from the multiple graphics processing units are direct inputs to first stage image combiners and outputs from at least two of the first stage image combiners are direct inputs to a second stage image combiner.

Applicant affirmatively rescinds the distinction from the teachings of Knittel, Kelleher, and Duluk based upon the feature of image combiners, wherein outputs from the multiple graphics processing units are direct inputs to first stage image combiners and outputs from at least two of the first stage image combiners are direct inputs to a second stage image combiner.

The September 5, 2006, and the March 22, 2007, Replies

In the Amendment and Reply Under 37 C.F.R. § 1.111 filed September 5, 2006, (hereinafter "the July 1, 2005, Reply") and the Amendment and Reply Under 37 C.F.R. § 1.111 filed March 22, 2007, (hereinafter "the March 22, 2007, Reply") Applicant amended claim 3 to distinguish the features of: (1) rendering the set of three-dimensional computer graphics data *to be* rendering substantially all of the three-dimensional computer graphics data rather than a sample of the set of three-dimensional computer graphics data and (2) allocating a set of three-dimensional computer graphics data such that the set of three-dimensional computer graphics data corresponds to portions of the scene that lies within rectangular subvolumes to which the multiple graphics processing units have been assigned *to be* allocating a set of three-dimensional computer graphics data such that the set of three-dimensional computer graphics data corresponds to substantially all of a scene that lie within rectangular subvolumes to which the multiple graphics processing units have been assigned

to distinguish claim 3 from the teachings of Knittel and U.S. Patent No. 5,760,781 to Kaufman *et al.* (hereinafter "Kaufman"). Claim 9 was amended in a similar manner.

However, in addition to this distinction, neither Knittel nor Kaufman, alone or in combination, discloses, teaches, or suggests allocating, to multiple graphics processing units, three-dimensional computer graphics data such that the allocated three-dimensional computer graphics data corresponds to a portion of a scene that lies within rectangular subvolumes to which the multiple graphics processing units have been assigned, wherein a measure of a first dimension of a first rectangular subvolume of the rectangular subvolumes is different from a measure of the first dimension of a second rectangular subvolume of the rectangular subvolumes.

Because the feature wherein a measure of a first dimension of a first rectangular subvolume of the rectangular subvolumes is different from a measure of the first dimension of a second rectangular subvolume of the rectangular subvolumes is sufficient to render each of claims 3 and 9 patentable over Knittel and Kaufman, Applicant, in the present Amendment and Reply Under 37 C.F.R. 1.111, amended each of claims 3 and 9: (1) to restore the feature of allocating a set of three-dimensional computer graphics data such that the set of three-dimensional computer graphics data corresponds to portions of the scene that lies within rectangular subvolumes to which the multiple graphics processing units have been assigned and (2) to broaden the element of rendering substantially all of the three-dimensional computer graphics data rather than a sample of the set of three-dimensional computer graphics data *to be* rendering the allocated three-dimensional computer graphics data.

Applicant affirmatively rescinds the distinction from the teachings of Knittel and Kaufman based upon the features of: (1) allocating a set of three-dimensional computer

graphics data such that the set of three-dimensional computer graphics data corresponds to *substantially all* of a scene that lies within rectangular subvolumes to which the multiple graphics processing units have been assigned and (2) rendering *substantially all* of the three-dimensional computer graphics data *rather than a sample* of the set of three-dimensional computer graphics data.

Rejections Under 35 U.S.C. § 103

At page 2 of the Office Action, claims 2-5, 7, 9, and 10 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Knittel in view of Kaufman. Applicant respectfully traverses these rejections.

Amended independent claim 3 recites (emphasis added):

> A method for presenting three-dimensional computer graphics images using multiple graphics processing units, comprising the steps of:
>
> (1) allocating, to the multiple graphics processing units, three-dimensional computer graphics data such that said allocated three-dimensional computer graphics data corresponds to a portion of a scene that lies within rectangular subvolumes to which the multiple graphics processing units have been assigned;
>
> (2) rendering, by the multiple graphics processing units, said allocated three-dimensional computer graphics data;
>
> (3) combining said rendered three-dimensional computer graphics data, thereby producing a three-dimensional computer graphics image; and
>
> (4) presenting, for viewing, said combined three-dimensional computer graphics image;
>
> ***wherein a measure of a first dimension of a first rectangular subvolume of the rectangular subvolumes is different from a measure of the first dimension of a second rectangular subvolume of the rectangular subvolumes.***

Independent claim 9 has been amended in a similar manner.

Support for these amendments can be found at paragraph 32 of the specification of the present patent application: "Note that the dimensions of the sides of the rectangular volume or subvolumes do not need to equal one another."

Neither Knittel nor Kaufman, alone or in combination, discloses, teaches, or suggests allocating, to multiple graphics processing units, three-dimensional computer graphics data such that the allocated three-dimensional computer graphics data corresponds to a portion of a scene that lies within rectangular subvolumes to which the multiple graphics processing units have been assigned, wherein a measure of a first dimension of a first rectangular subvolume of the rectangular subvolumes is different from a measure of the first dimension of a second rectangular subvolume of the rectangular subvolumes.

In contrast, Knittel, at column 15, lines 51-67 through column 16, lines 1-15, teaches (emphasis added):

> Sectioning a volume data set
>
> In one embodiment, the volume data set is rendered a section at the time. FIG. **8** illustrates the manner in which the volume data set **10** is processed as sections **340** in the x direction. Each section **340** is defined by boundaries, which in the illustrated embodiment include respective pairs of boundaries in the x, y and z dimensions. In the case of the illustrated x-dimension sectioning, the top, bottom, front and rear boundaries of each section **340** coincide with corresponding boundaries of the volume data set **10** itself. Similarly, the left boundary of the left-most section **340-1** and the right boundary of the right-most section **340-8** coincide with the left and right boundaries respectively of the volume data set **10**. All the remaining section boundaries are boundaries separating sections **340** from each other.
>
> In the illustrated embodiment, the data set **10** is 256voxels wide in the x direction. These 256 voxels are divided into eight sections **340**, each of which is thirty-two voxels wide. Each section **340** is rendered separately in order to reduce the amount of FIFO storage required within the processing element **210**.
>
> In the illustrated embodiment, *the volume data set may be arbitrarily wide in the x direction provided it is partitioned into sections of* ***fixed width***. The size of the volume data set **10** in the y direction is limited by the sizes of FIFO buffers, such as buffers **106** and **114** of FIG. **5**A, and the size of the

> volume data set **10** in the z direction is limited by the size of a section memory which is described below. However, from a practical point of view, independence of view direction limits the size of the volume in all three directions.

Likewise, Kaufman, at column 5, lines 52-67 through column 6, lines 1-38, teaches (emphasis added):

> The method and apparatus of the present invention are capable of manipulating data and supporting real-time visualization of high resolution voxel-based data sets. The method and apparatus are designed for use as a voxel-based system as described in the issued patents and pending applications of Arie Kaufman, a named inventor of this application, including "Method Of Converting Continuous Three-Dimensional Geometrical Representations Into Discrete Three-Dimensional Voxel-Based Representations Within A Three-Dimensional Voxel-Based System", which issued an Aug. 6, 1991, as ***U.S. Pat. No. 5,038,302***; "Method Of Converting Continuous Three-Dimensional Geometrical Representations Of Polygonal Objects Into Discrete Three-Dimensional Voxel-Based Representations Thereof Within a Three-Dimensional Voxel-Based System", which issued on Jan. 22, 1991, as U.S. Pat. No. 4,987,554; "Method And Apparatus For Storing, Accessing, And Processing Voxel-Based Data", which issued on Jan. 15, 1991, as U.S. Pat. No. 4,985,856; "Method Of Converting Continuous Three-Dimensional Geometrical Representations of Quadratic Objects Into Discrete Three-Dimensional Voxel-Based Representations Thereof Within A Three-Dimensional Voxel-Based System", which was filed on May 4, 1989, as Ser. No. 07/347,593, which was abandoned in favor of U.S. Ser: No. 08/031,599, filed on Mar. 15, 1993 as a continuation application of the '593 application; "Method And Apparatus For Generating Arbitrary Projections Of Three-Dimensional Voxel-Based Data", which issued on Mar. 31, 1992 as U.S. Pat. 5,101,475; "Method And Apparatus For Real-Time Volume Rendering From An Arbitrary Viewing Direction", which was filed on Jul. 26, 1993, as U.S. Ser. No. 08/097,637; and "Method And Apparatus For Generating Realistic Images Using A Discrete Representation", which was filed on Mar. 20, 1992, as U.S. Ser. No. 07/855,223, the entire disclosure of each of these references is incorporated herein by reference.
>
> Referring now to FIG. **3**, the apparatus of the present invention **20** preferably includes six basic components. These include a cubic frame buffer **22** having a plurality of memory storage units capable of storing voxels therein, three two-dimensional (2-D) buffers **24** and an interconnection mechanism **26** coupling the cubic frame buffer to each of the 2-D buffers. ***The cubic frame buffer is a three-dimensional (3-D) memory organized in n memory modules (or memory slices), wherein each memory module has n^2 memory storage units as described in the above-identified references.*** The

> cubic frame buffer also includes an independent dual access and addressing unit (not shown in the figures). A 3-D skewed memory organization, as described in the above-identified references, enables conflict-free access of any beam (i.e., a ray parallel to a main axis of the cubic frame buffer). The apparatus also includes an interpolation mechanism **28**, shading mechanism **30** and projection mechanism **32**.

Referring to U.S. Patent No. 5,038,302, it, at column 1, lines 54-60, teaches (emphasis added):

> [T]he 3-D computer graphic workstation **1** is based upon 3-D voxel-based representation of objects within a large 3-D memory **2** referred to hereinafter as a 3-D Cubic Frame Buffer, which comprises specially organized memory modules (not shown) containing a cellular array of ***unit cubic cells*** called voxels.

Accordingly, claims 3 and 9 are patentable over Knittel in view of Kaufman. Because each of claims 2, 4, 5, 7, and 10 depends upon claims 3 or 9 and because of the additional distinctive features of each of claims 2, 4, 5, 7, and 10, these claims are also patentable over Knittel in view of Kaufman. Therefore, Applicant respectfully requests that the Examiner remove his rejections of claims 2-5, 7, 9, and 10 under 35 U.S.C. § 103(a) and pass these claims to allowance.

New Claims

Applicant has added new claims 13-16, each of which depends upon claims 3 or 9. Because each of new claims 13-16 depends upon claims 3 or 9 and because of the additional distinctive features of each of new claims 13-16, these claims are also patentable over Knittel in view of Kaufman. Therefore, Applicant respectfully requests that the Examiner pass new claims 13-16 to allowance.

Conclusion

All of the stated grounds of rejection have been traversed. Applicant therefore respectfully requests that the Examiner reconsider all presently outstanding rejections and that they be withdrawn. Applicant believes that a full and complete reply has been made to the outstanding Office Action and, as such, the present application is in condition for allowance. If the Examiner believes, for any reason, that personal communication will expedite prosecution of this application, the Examiner is invited to telephone the undersigned at the number provided.

Prompt and favorable consideration of this Amendment and Reply is respectfully requested.

Respectfully submitted,

STERNE, KESSLER, GOLDSTEIN & FOX P.L.L.C.

Timothy A. Doyle
Attorney for Applicant
Registration No. 51,262

Date: 1 AUG 07

1100 New York Avenue, N.W.
Washington, D.C. 20005-3934
(202) 371-2600